RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.:	**256-8321**
SRP Section:	**09.02.02 – Reactor Auxiliary Cooling water Systems**
Application Section:	**9.2.2**
Date of RAI Issue:	**10/19/2015**

Question No. 09.02.02-8

The Component Cooling Water System (CCWS) must be designed so that it is capable of transferring the heat generated by all the heat loads being serviced by the system to the Essential Service Water System for rejection to the ultimate heat sink in order to satisfy GDC 44. In SRP 9.2.2, Section III Item 3D indicates that the system will be reviewed to see that the system is designed for removal of heat loads during normal power operation and for emergency core cooling heat loads during accident conditions with appropriate design margins for adequate operation. The applicant did not state or justify the amount of excess margins that are included in the design to account for uncertainties, component wear and aging effects, fouling of heat transfer surfaces, etc. Therefore, the applicant is requested to identify, in the DCD, margins in the design and discuss why the specified margins are considered to be adequate.

Response

The CCW has a total of six heat exchangers, three per division to transfer heat loads to the ESW system. The CCW heat exchanger (HX) duties of division I from DCD Table 9.2.2-3B are summarized as follows:

- ✓ Normal Power Operation (128.73 x 10^6 BTU/hour),
- ✓ Initial Shutdown (up to 3.5 hours, 273.83 x 10^6 BTU/hour),
- ✓ Refueling Operation (112.40 x 10^6 BTU/hour),
- ✓ Design Basis Accident (SIAS, 83.63 x 10^6 BTU/hour),
- ✓ Design Basis Accident (CSAS, 191.43 x 10^6 BTU/hour), and
- ✓ Safe Shutdown Operation (361.80 x 10^6 BTU/hour).

The DCD Tables 9.2.2-3A/B contain the two divisions of CCW heat loads for different modes of operation (indicated on the top row of each page). It is noted that the total heat load in each mode of operation is spread between the number of heat exchangers in each of the two divisions. For example, during normal power operation, two heat exchangers in each division are operating. Therefore the total heat load in each division is spread between the two heat exchangers and the third heat exchanger will be in standby mode. In the normal shutdown and refueling mode, all six heat exchangers in both divisions are operating initially and the cooling loads are dissipated with shutdown cooling.

KHNP performed a heat load evaluation for each operating heat exchanger based on the heat load requirements for different modes of operation with the respective number of CCW HXs and the log mean temperature differences, and concluded that the normal power operation is the CCW heat exchanger sizing condition since the UA value for normal power operation is the largest among the other modes of operation. The evaluation results are as follows:

Table 1 CCW Heat Exchanger Sizing Evaluation for Different Modes of Operation

Div. 1 Operational Mode	HX Operating	Heat Exchanger UA** Million BTU/hr/ºF	Margin*
Normal Power	2	16.53	Base case
Shutdown Cooling + 3.5 hrs	3	4.98	70%
Refueling	3	8.39	49%
Design Basis Accident SIAS	2	2.31	86%
Design Basis Accident CSAS	2	5.67	66%
Safe Shutdown	2	11.52	30%

* Margin = (normal power case – other operational case)/normal power case

** Derived from q = U*A*LMTD; U*A = q/LMTD, where U represents the overall heat transfer coefficient, which include fouling factors; and A is the total heat transfer area in the individual CCW heat exchanger.

In performing the evalution above, there is no additional margin included in the CCW HX sizing evaluation. However, the duties for the normal power operation contains various levels of conservatism built into the heat exchanger duties. For example: the duty for the SFP cooling HXs for normal power, shutdown, and design basis accidents operations is based on refueling core off-load (about one-third of one full core off-load) and simultaneous with the 20 years of residual spent fuel decay heat in the spent fuel pool. The duty for the SFP cooling HXs during refueling operations is based on one full core off-load and simultaneous with the 20 years of residual spent fuel decay heat. The SFP cooling HX heat load calculation excludes the actual process time of off-load and refueling operations. Since the heat load of the spent fuel is the largest when the fuel is just taken out of the reactor; therefore, the exclusion of actual process time results in a larger heat load. The following assumptions are listed as follows:

- The heat load of one full core off-load during the refueling operation is determined at 100 hours after the reactor shutdown without transportation time from the reactor to the SFP.

- The heat load of one-third of full core off-load during normal power, shutdown, and design basis accidents operations is determined without the period for the fuels to be cooled in the SFP during the refueling operation; i.e., the one-third of heat load that is determined for the refueling operation is selected.

- Even though the 20 years of residual spent fuel decay heat is based on 14 times of refueling process, 15 times of refueling process are considered.

No credit for margin is taken during the above operations.

The CCW side uses demineralized water with corrosion inhibibors to minimize the chemical corrosion and fouling. The CCW fouling factors, including wear, aging (chemical degradation), and fouling, are included in the devleopment of the overall heat transfer coefficient (U), are considered to be insignificant when it is compared to the ESW side, which is exposed to the environment. In minimizing the fouling impacts, DCD Tier 2 Subsection 9.2.2.4 stipulates periodic inspection and testing to verify performance of the system and individual components in order to maintain the desired heat transfer as designed.

The calculated UA of 16.53 BTU/hr/ºF stated in Table 1 is a required value for the CCW HX sizing to ensure heat removal capability. The actual design UA includes the consideration of uncertainties, component wear and aging effects, fouling of heat transfer surfaces, etc. Therefore, the heat exchanger is designed to incldue a minimum of 10 percent margin for the considerations discussed above and to permit the addition of a minimum 20 percent increase in plates by the vendor in the final procurement.

Based on the above discussion, DCD Tier 2 Subsection 9.2.2.2.2.1 will be revised as indicated in the Attachment.

Impact on DCD

DCD Tier 2 Subsection 9.2.2.2.2.1 will be revised as indicated in the Attachment.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environment Report.

Motor-operated valves are installed on the CCW supply and return lines to RCPs. These valves can be used to isolate the in-leakage due to an RCP high-pressure seal cooler tube rupture.

9.2.2.2.2 Component Description

Table 9.2.2-4 shows the design parameters of the major components. Each component is described in the following subsections.

9.2.2.2.2.1 CCW Heat Exchangers

Six plate-type CCW heat exchangers, three per division, are provided to handle the essential and nonessential cooling requirements. The heat exchangers are designed to maintain cooling water in the heat exchanger outlet at 35 °C (95 °F) or less during normal power operation and equal to or less than 43.3 °C (110 °F) during normal shutdown or emergency operating modes.

Each operational mode uses a different CCW heat exchanger alignment. The alignments are as follows:

Normal power operation:	Two HXs per division
Normal shutdown	All six HXs from both divisions
Safe shutdown	Two HXs in a single division
Post-LOCA	Two HXs in a single division

~~The frame of the heat exchanger is designed to permit the future installation of a minimum of 20 percent additional plates by the vendor in the final procurement. The fouling factor for each heat exchanger is based on the manufacturer's standards and system water chemistry.~~

The heat exchanger is designed to include a minimum of 10 percent margin for uncertainties, component wear and aging effects, fouling of heat transfer surfaces, etc., based on the manufacturer's standards and system water chemistry, and to permit the addition of a minimum 20 percent increase in plates by the vendor in the final procurement.

9.2.2.2.2.2 CCW Pumps

Four identical CCW pumps are provided in both divisions. One pump per division is in service during normal power operation. When the cooling water flow from the operating